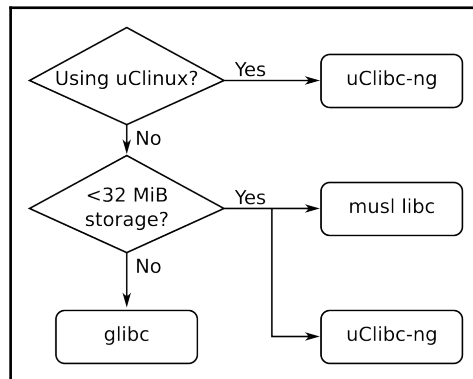
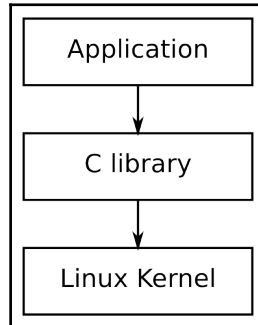


1

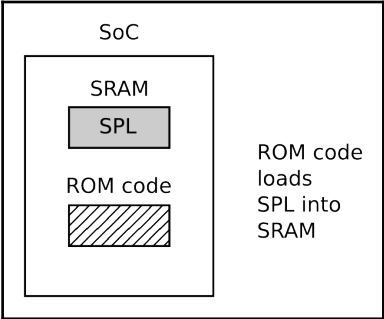
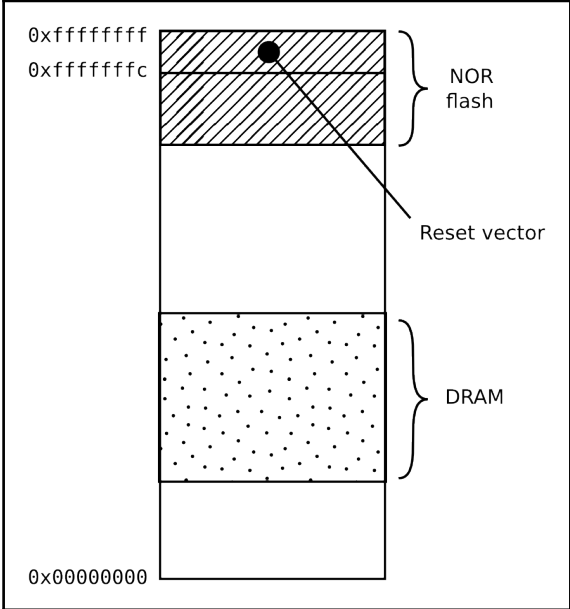
Starting Out

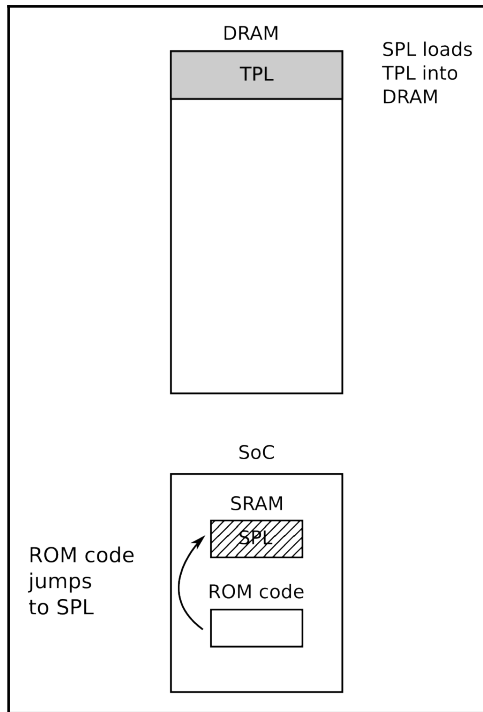
No Graphics Images for this Chapter

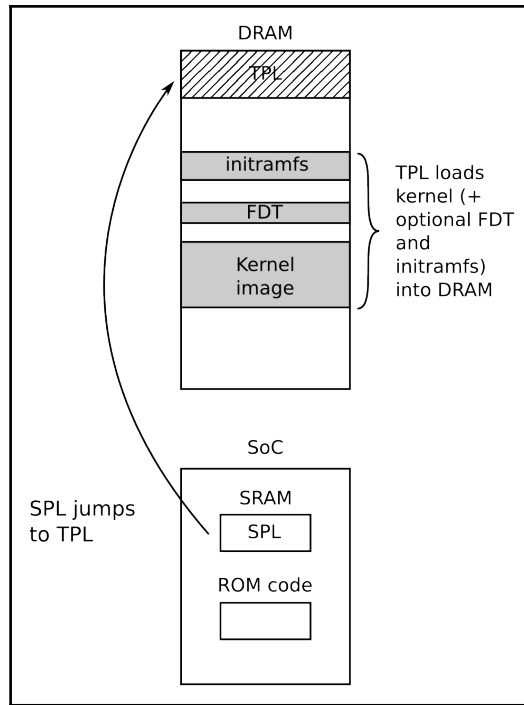
Learning About Toolchains



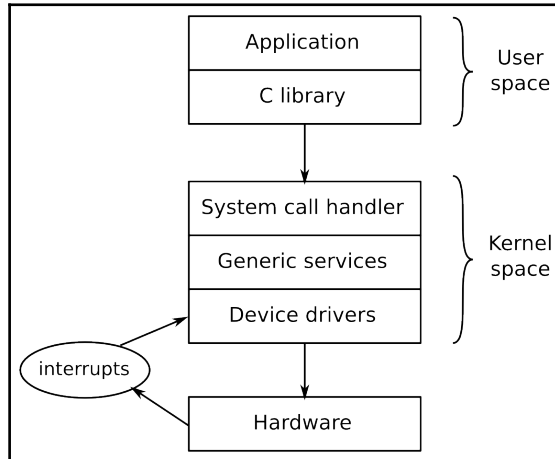
All About Bootloaders







Configuring and Building the Kernel



```
.config - Linux/arm 4.9.13 Kernel Configuration
> Device Drivers > Character devices
Character devices
Arrow keys navigate the menu. <Enter> selects submenus ---> (or empty
submenus ----). Highlighted letters are hotkeys. Pressing <Y>
includes, <N> excludes, <M> modularizes features. Press <Esc><Esc> to
exit, <?> for Help, </> for Search. Legend: [*] built-in [ ]
^(-)
< > Trace data sink for MIPI P1149.7 cJTAG standard
[*] /dev/mem virtual device support
[*] /dev/kmem virtual device support
Serial drivers --->
< > TTY driver to output user messages via printk
[ ] ARM JTAG DCC console
<*> Virtio console
< > IPMI top-level message handler ----
<*> Hardware Random Number Generator Core support --->
< > Siemens R3964 line discipline
+ (+)
<Select> < Exit > < Help > < Save > < Load >
```

```
.config - Linux/arm 4.9.13 Kernel Configuration
> General setup
      General setup
Arrow keys navigate the menu. <Enter> selects submenus ---> (or empty
submenus ----). Highlighted letters are hotkeys. Pressing <Y>
includes, <N> excludes, <M> modularizes features. Press <Esc><Esc> to
exit, <?> for Help, </> for Search. Legend: [*] built-in [ ]

  ( ) Cross-compiler tool prefix
  [ ] Compile also drivers which will not load
  [*] (-melp-v1.0) Local version - append to kernel release
  [*] Automatically append version information to the version string
      Kernel compression mode (Gzip) --->
  ((none)) Default hostname
  [*] Support for paging of anonymous memory (swap)
  [*] System V IPC
  [ ] POSIX Message Queues
  [*] Enable process_vm_readv/writev syscalls
  ↓(+)
```

<Select> < Exit > < Help > < Save > < Load >

Building a Root Filesystem

400	r-----	}	Owner permissions
200	-w-----		
100	--x-----		
040	---r-----	}	Group permissions
020	----w----		
010	-----x---		
004	-----r--	}	World permissions
002	-----w-		
001	-----x		

Selecting a Build System

```
/home/chris/buildroot/.config - Buildroot 2017.02.1 Configuration
> Bootloaders

                                Bootloaders
Arrow keys navigate the menu. <Enter> selects submenus ---> (or empty
submenus ----). Highlighted letters are hotkeys. Pressing <Y>
selects a feature, while <N> will exclude a feature. Press
<Esc><Esc> to exit, <?> for Help, </> for Search. Legend: [*] feature

[ ] afboot-stm32
[ ] Barebox
[ ] mxs-bootlets
[ ] s500-bootloader
[ ] ts4800-mbrboot
[*] U-Boot
    Build system (Kconfig) --->
    U-Boot Version (Custom version) --->
(2017.01) U-Boot version
(board/melp/nova/0001-BSP-for-Nova.patch) Custom U-Boot patches
    U-Boot configuration (Using an in-tree board defconfig file
(am335x_evm) Board defconfig
[*] U-Boot needs dtc
L(+)

<Select> < Exit > < Help > < Save > < Load >
```

```
/home/chris/buildroot/.config - Buildroot 2017.02.1 Configuration
> Kernel
Kernel
Arrow keys navigate the menu. <Enter> selects submenus ---> (or empty
submenus ----). Highlighted letters are hotkeys. Pressing <Y>
selectes a feature, while <N> will exclude a feature. Press
<Esc><Esc> to exit, <?> for Help, </> for Search. Legend: [*] feature

[*] Linux Kernel
Kernel version (Custom version) --->
(4.9.13) Kernel version
() Custom kernel patches
Kernel configuration (Using an in-tree defconfig file) ---
(omap2plus) Defconfig name
() Additional configuration fragment files
Kernel binary format (zImage) --->
Kernel compression format (gzip compression) --->
[*] Build a Device Tree Blob (DTB)
Device tree source (Use a custom device tree file) --->
(b)oard/melp/nova/nova.dts Device Tree Source file paths
[ ] Install kernel image to /boot in target
L(+)
```

<Select> < Exit > < Help > < Save > < Load >

```
/home/chris/buildroot/.config - Buildroot 2017.02.1 Configuration
> Toolchain
Toolchain
Arrow keys navigate the menu. <Enter> selects submenus ---> (or empty
submenus ----). Highlighted letters are hotkeys. Pressing <Y>
selectes a feature, while <N> will exclude a feature. Press
<Esc><Esc> to exit, <?> for Help, </> for Search. Legend: [*] feature

Toolchain type (Buildroot toolchain) --->
*** Toolchain Buildroot Options ***
(buildroot) custom toolchain vendor name
C library (uClibc-ng) --->
*** Kernel Header Options ***
Kernel Headers (Same as kernel being built) --->
Custom kernel headers series (4.9.x) --->
*** uClibc Options ***
(package/uClibc/uClibc-ng.config) uClibc configuration file to us
() Additional uClibc configuration fragment files
[ ] Enable RPC support
[ ] Enable WCHAR support
[ ] Enable toolchain locale/i18n support
L(+)
```

<Select> < Exit > < Help > < Save > < Load >

```

/media/chris/android/home/training/MELP/ch06/buildroot/.config - Buildroot 2017
-> System configuration
      System configuration
      Arrow keys navigate the menu. <Enter> selects submenus ---> (or empty
      submenus ----). Highlighted letters are hotkeys. Pressing <Y>
      selectes a feature, while <N> will exclude a feature. Press
      <Esc><Esc> to exit, <?> for Help, </> for Search. Legend: [*] feature
      ^(-)
      ( ) Network interface to configure through DHCP
      [*] Purge unwanted locales
      (C en_US) Locales to keep
      [ ] Install timezone info
      ( ) Path to the users tables
      ( ) Root filesystem overlay directories
      ( ) Custom scripts to run before creating filesystem images
      ( ) Custom scripts to run inside the fakeroot environment
      (board/melp/nova/post-image.sh) Custom scripts to run after creat
      ( ) Extra arguments passed to custom scripts

      <Select>  < Exit >  < Help >  < Save >  < Load >

```

```

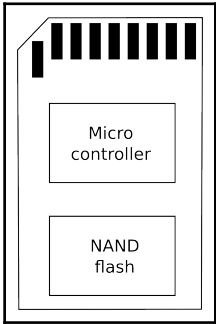
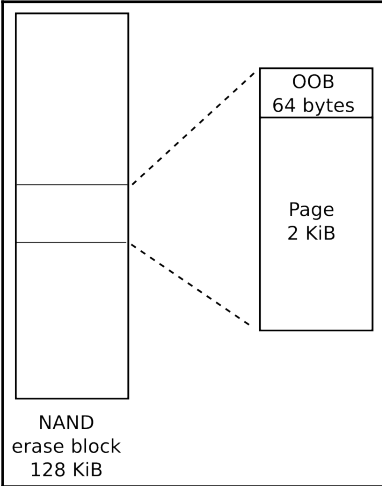
[ 8.179808] md: If you don't use raid, use raid=noautodetect
[ 8.193152] md: Autodetecting RAID arrays.
[ 8.197292] md: Scanned 0 and added 0 devices.
[ 8.201323] md: autorun ...
[ 8.204339] md: ... autorun DONE.
[ 8.214568] EXT4-fs (vda): couldn't mount as ext3 due to feature incompatibil
ities
[ 8.224943] EXT4-fs (vda): couldn't mount as ext2 due to feature incompatibil
ities
[ 8.267365] EXT4-fs (vda): mounted filesystem with ordered data mode. Opts: (
null)
[ 8.276284] UFS: Mounted root (ext4 filesystem) on device 253:0.
[ 8.283072] devtmpfs: mounted
[ 8.305016] Freeing unused kernel memory: 412K (c0945000 - c09ac000)
[ 8.310417] This architecture does not have kernel memory protection.
INIT: version 2.88 booting

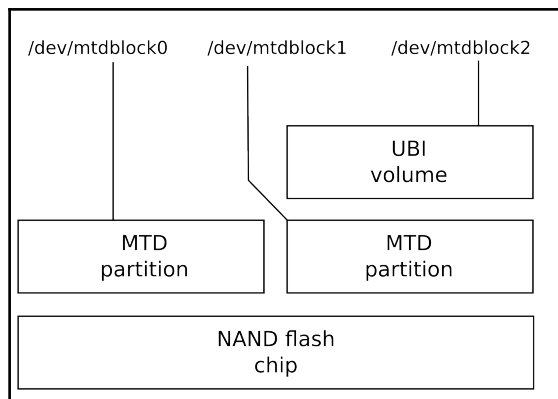
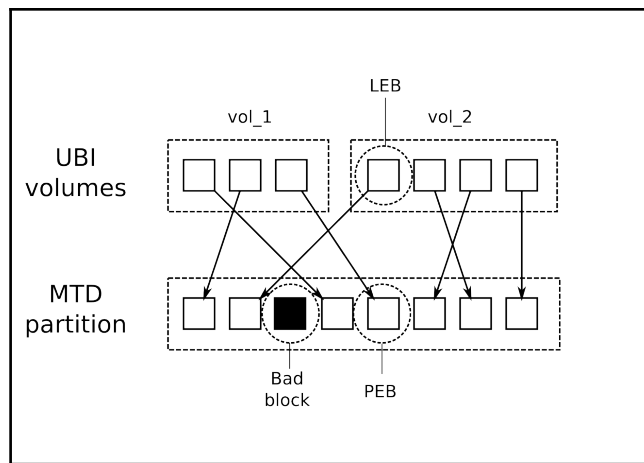
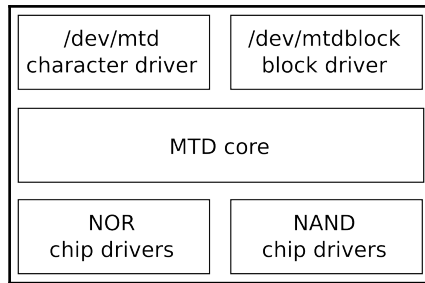
Please wait: booting...
Starting udev
[ 9.316513] udevd[115]: starting version 3.2
[ 9.436544] udevd[116]: starting eudev-3.2
[ 12.073243] EXT4-fs (vda): re-mounted. Opts: data=ordered
Populating dev cache
INIT: Entering runlevel: 5
Configuring network interfaces... done.
Starting syslogd/klogd: done

Poky (Yocto Project Reference Distro) 2.2.1 qemuarm /dev/tty1
qemuarm login:

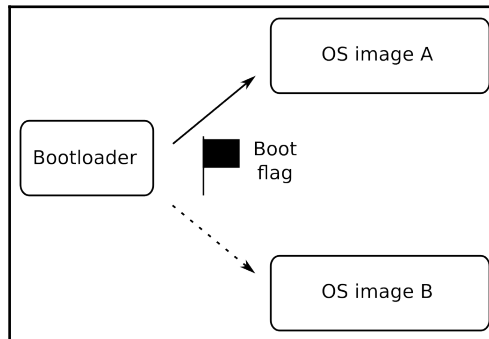
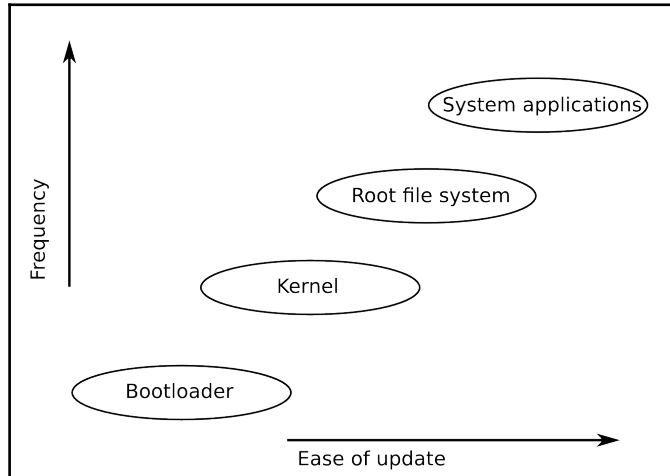
```

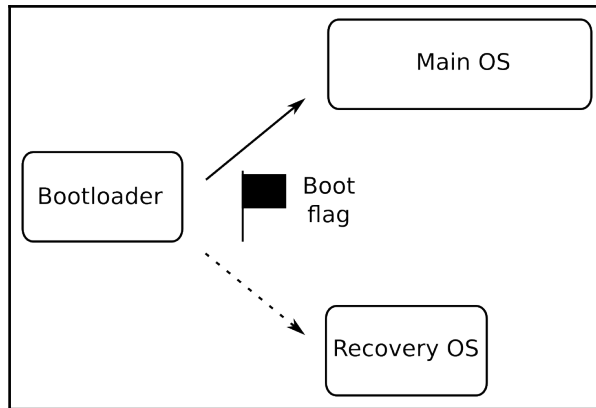
Creating a Storage Strategy

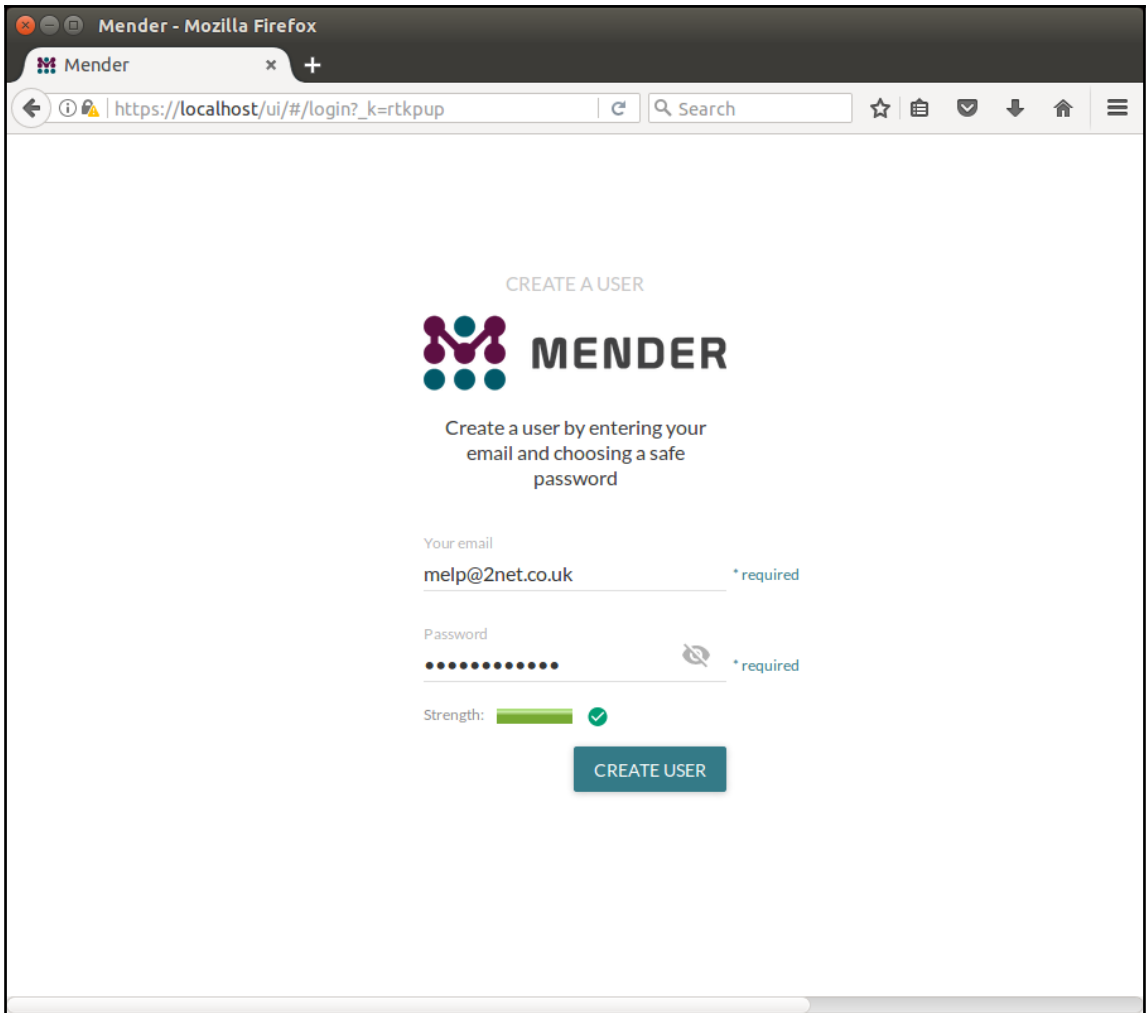




Updating Software in the Field







Mender - Mozilla Firefox

Mender

https://localhost/ui/#/devices

MENDER

Mender is currently running in demo mode. See the documentation for help switching to production mode

DASHBOARD DEVICES ARTIFACTS DEPLOYMENTS

Groups

All devices 2

+ Create a group

All devices

FILTERS

ID	Device type	Current software	Last heartbeat
<input type="checkbox"/> ac0d42c	-	-	2017-05-08 19:21
<input type="checkbox"/> 71f94a5	vexpress-qemu	release-1	2017-05-08 19:34

Device identity

ID
71f94a573db619e49c73cc36
1801b1ebd87ff5f4fe884bf71

mac
52:54:00:81:91:19

Device inventory

artifact_name release-1	mac_eth0 52:54:00:81:91:19
cpu_model ARMv7 Processor rev 0 (v7l)	mem_total_kb 122948
device_type vexpress-qemu	mender_client_version 1.0.1
hostname vexpress-qemu	network_interfaces eth0
ipv4_eth0 10.0.2.15/24	
kernel Linux version 4.1.36-yocto-stand...	

↻ Create a deployment for this device

< 1 / 1 >



Interfacing with Device Drivers

No Graphics Images for this Chapter



Starting Up – The init Program

No Graphics Images for this Chapter

Managing Power

```
PowerTOP 2.8 Overview Idle stats Frequency stats Device stats Tunables
Summary: 4.2 wakeups/second, 0.0 GPU ops/seconds, 0.0 VFS ops/sec and 0.4% CPU use

Usage      Events/s  Category  Description
257.0 us/s 1.0       kWork     phy_state_machine
 2.3 ms/s  0.15      Process   powertop
72.0 us/s  0.6       Timer     tick_sched_timer
54.7 us/s  0.6       Process   [rcu_preempt]
35.0 us/s  0.5       kWork     cache_reap
 8.1 us/s  0.5       kWork     vmstat_shepherd
 0.9 ms/s  0.05      Process   [irq/159-44e0b00]
 6.2 us/s  0.25      Process   [watchdog/0]
24.4 us/s  0.20      Process   init [5]
 1.4 us/s  0.15      kWork     neigh_periodic_work
50.7 us/s  0.10      Interrupt [3] net_rx(softirq)
 1.4 us/s  0.10      kWork     cpts_overflow_check
189.8 us/s 0.00      Interrupt [159] 44e0b000.i2c
41.2 us/s  0.05      kWork     rb_free_work
 6.8 us/s  0.05      kWork     flush_to_ldisc
 0.3 us/s  0.05      Timer     sched_clock_poll
77.8 us/s  0.00      Process   /usr/sbin/dropbear -r /etc/dropbear/d
62.5 us/s  0.00      Process   [kworker/0:1]

<ESC> Exit | <TAB> / <Shift + TAB> Navigate |
```

```
PowerTOP 2.8 Overview Idle stats Frequency stats Device stats Tunables

Package | CPU 0
300 MHz 38.6% | 300 MHz 38.6%
600 MHz 43.7% | 600 MHz 43.7%
720 MHz 0.0%  | 720 MHz 0.0%
800 MHz 0.0%  | 800 MHz 0.0%
1000 MHz 0.4% | 1000 MHz 0.4%
Idle    17.2% | Idle    17.2%

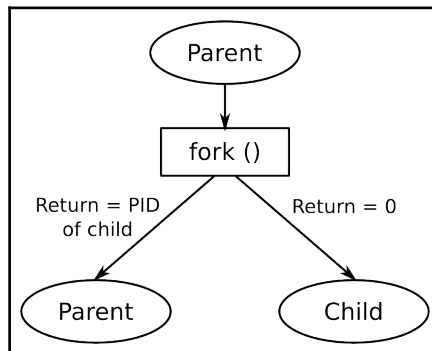
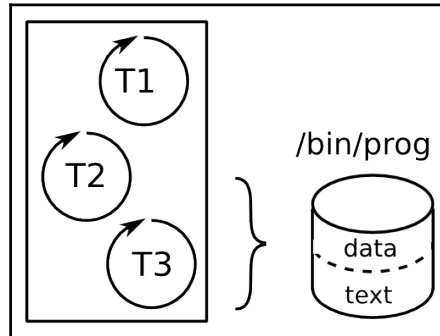
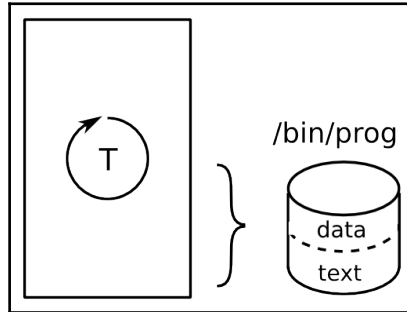
<ESC> Exit | <TAB> / <Shift + TAB> Navigate |
```

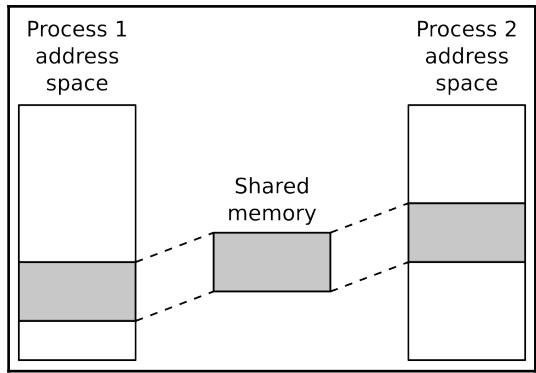
```
PowerTOP 2.8  Overview  Idle stats  Frequency stats  Device stats  Tunables

Package | CPU 0
WFI     32.6% | WFI     32.6%  0.6 ms
C1      54.6% | C1      54.5% 238.2 ms

<ESC> Exit | <TAB> / <Shift + TAB> Navigate |
```

Learning About Processes and Threads

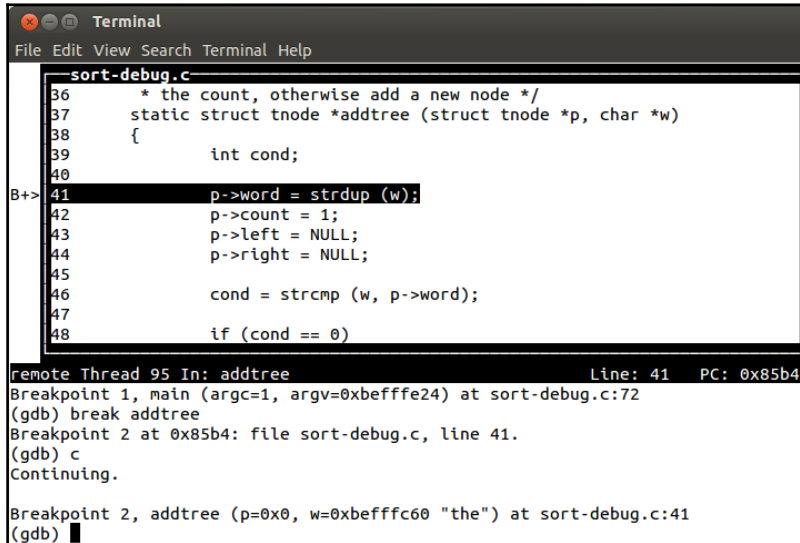




Managing Memory

No Graphics Images for this Chapter

Debugging with GDB

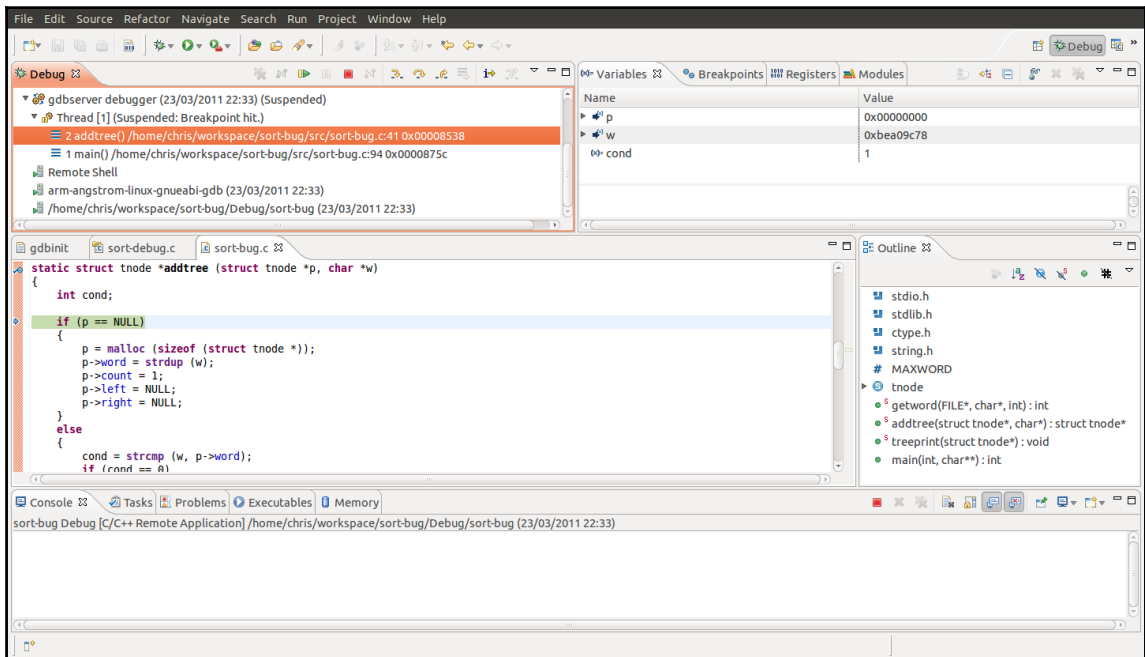
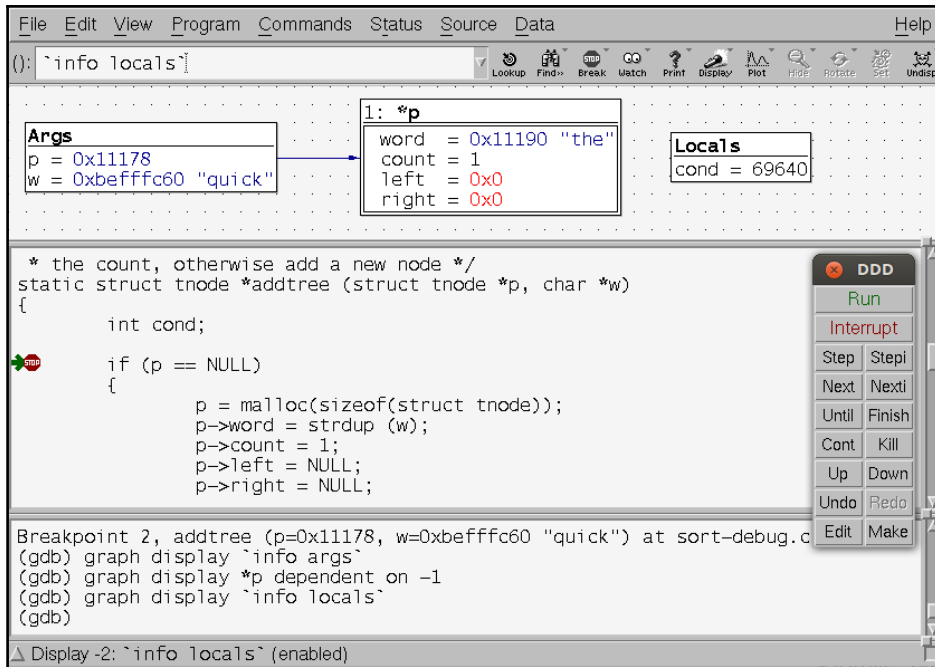


```
Terminal
File Edit View Search Terminal Help

sort-debug.c
36  * the count, otherwise add a new node */
37  static struct tnode *addtree (struct tnode *p, char *w)
38  {
39      int cond;
40
41  B+> 41      p->word = strdup (w);
42      p->count = 1;
43      p->left = NULL;
44      p->right = NULL;
45
46      cond = strcmp (w, p->word);
47
48      if (cond == 0)

remote Thread 95 In: addtree Line: 41 PC: 0x85b4
Breakpoint 1, main (argc=1, argv=0xbefffe24) at sort-debug.c:72
(gdb) break addtree
Breakpoint 2 at 0x85b4: file sort-debug.c, line 41.
(gdb) c
Continuing.

Breakpoint 2, addtree (p=0x0, w=0xbefffc60 "the") at sort-debug.c:41
(gdb) █
```



Profiling and Tracing

```
Samples: 9K of event 'cycles', Event count (approx.): 2006177260
11.29% grep libc-2.20.so      [.] re_search_internal
 8.80% grep busybox.nosuid    [.] bb_get_chunk_from_file
 5.55% grep libc-2.20.so      [.] _int_malloc
 5.40% grep libc-2.20.so      [.] _int_free
 3.74% grep libc-2.20.so      [.] realloc
 2.59% grep libc-2.20.so      [.] malloc
 2.51% grep libc-2.20.so      [.] regexec@GLIBC_2.4
 1.64% grep busybox.nosuid    [.] grep_file
 1.57% grep libc-2.20.so      [.] malloc_consolidate
 1.33% grep libc-2.20.so      [.] strlen
 1.33% grep libc-2.20.so      [.] memset
 1.26% grep [kernel.kallsyms] [k] __copy_to_user_std
 1.20% grep libc-2.20.so      [.] free
 1.10% grep libc-2.20.so      [.] _int_realloc
 0.95% grep libc-2.20.so      [.] re_string_reconstruct
 0.79% grep busybox.nosuid    [.] xrealloc
 0.75% grep [kernel.kallsyms] [k] __do_softirq
 0.72% grep [kernel.kallsyms] [k] preempt_count_sub
 0.68% find [kernel.kallsyms] [k] __do_softirq
 0.53% grep [kernel.kallsyms] [k] __dev_queue_xmit
 0.52% grep [kernel.kallsyms] [k] preempt_count_add
 0.47% grep [kernel.kallsyms] [k] finish_task_switch.isra.85
Press '?' for help on key bindings
```

```
Samples: 10K of event 'cycles', Event count (approx.): 2256721655
- 9.95% grep libc-2.20.so      [.] re_search_internal
- re_search_internal
 95.96% 0
 3.50% 0x208
+ 8.19% grep busybox.nosuid    [.] bb_get_chunk_from_file
+ 5.07% grep libc-2.20.so      [.] _int_free
+ 4.76% grep libc-2.20.so      [.] _int_malloc
+ 3.75% grep libc-2.20.so      [.] realloc
+ 2.63% grep libc-2.20.so      [.] malloc
+ 2.04% grep libc-2.20.so      [.] regexec@GLIBC_2.4
+ 1.43% grep busybox.nosuid    [.] grep_file
+ 1.37% grep libc-2.20.so      [.] memset
+ 1.29% grep libc-2.20.so      [.] malloc_consolidate
+ 1.22% grep libc-2.20.so      [.] _int_realloc
+ 1.15% grep libc-2.20.so      [.] free
+ 1.01% grep [kernel.kallsyms] [k] __copy_to_user_std
+ 0.98% grep libc-2.20.so      [.] strlen
+ 0.89% grep libc-2.20.so      [.] re_string_reconstruct
+ 0.73% grep [kernel.kallsyms] [k] preempt_count_sub
+ 0.68% grep [kernel.kallsyms] [k] finish_task_switch.isra.85
+ 0.62% grep busybox.nosuid    [.] xrealloc
+ 0.57% grep [kernel.kallsyms] [k] __do_softirq
Press '?' for help on key bindings
```

```

re_search_internal /lib/libc-2.20.so
    cmp     r1,
    beq    c362c <gai_strerror+0xcaf8>
    str    r3, [fp, #-40]      ; 0x28
    b     c3684 <gai_strerror+0xcb50>
0.65     ldr    ip, [fp, #-256]   ; 0x100
0.16     ldr    r0, [fp, #-268] ; 0x10c
2.44     add    r3,
4.15     cmp    r0,
3.91     strle  r3, [fp, #-40]      ; 0x28
    ble    c3684 <gai_strerror+0xcb50>
4.72     ldrb   r1, [r2, #1]!
10.26    ldrb   r1, [ip, r1]
6.68     cmp    r1,
    beq    c3660 <gai_strerror+0xcb2c>
0.90     str    r3, [fp, #-40]      ; 0x28
2.12     ldr    r3, [fp, #-40]      ; 0x28
0.08     ldr    r2, [fp, #-268]   ; 0x10c
0.33     cmp    r2,
    bne    c3804 <gai_strerror+0xccd0>
0.08     mov    r3,
    ldr    r2, [fp, #-280]      ; 0x118
0.08     cmp    r3,
Press 'h' for help on key bindings

```

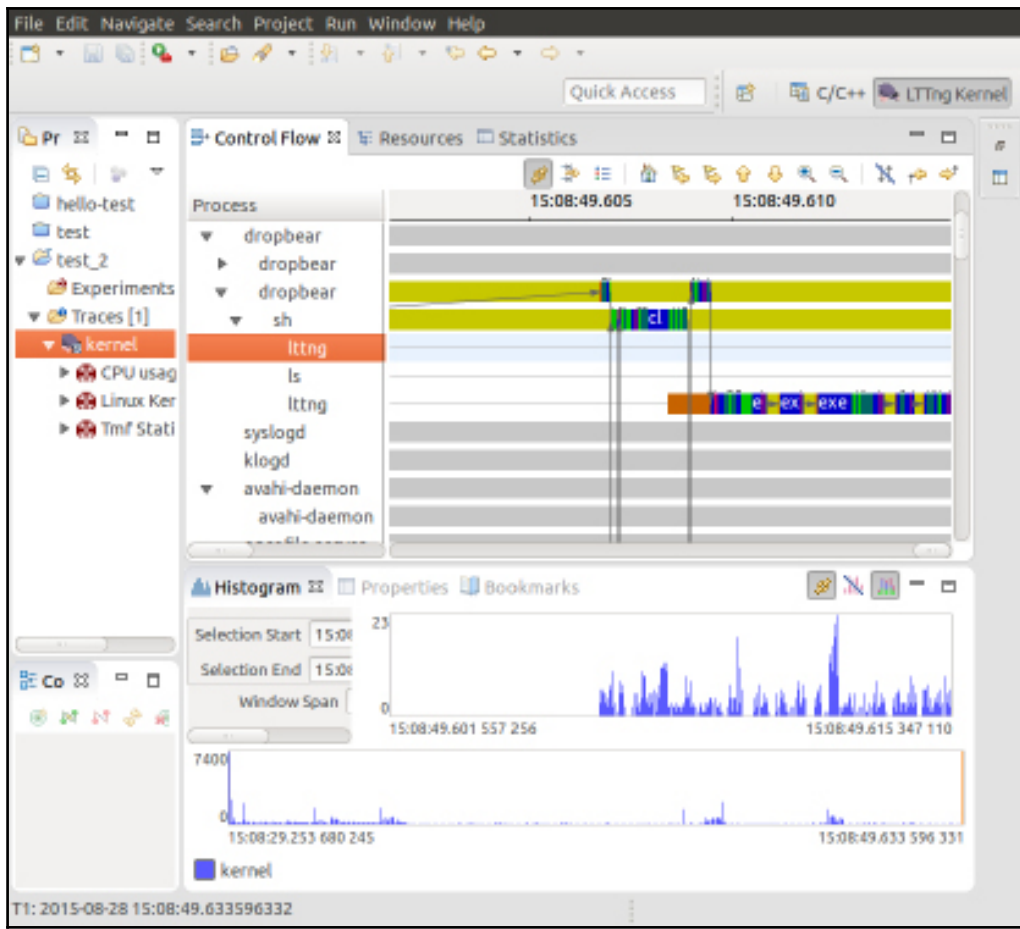
```

re_search_internal /lib/libc-2.20.so
    ++match_first;
    goto  forward_match_found_start_or_reached_end;

    case 6:
        /* Fastmap without translation, match forward. */
        while (BE (match_first < right_lim, 1)
4.15     cmp    r0,
3.91     strle  r3, [fp, #-40]      ; 0x28
    ble    c3684 <gai_strerror+0xcb50>
        && !fastmap[(unsigned char) string[match_first]])
4.72     ldrb   r1, [r2, #1]!
10.26    ldrb   r1, [ip, r1]
6.68     cmp    r1,
    beq    c3660 <gai_strerror+0xcb2c>
0.90     str    r3, [fp, #-40]      ; 0x28
        ++match_first;

    forward_match_found_start_or_reached_end:
        if (BE (match_first == right_lim, 0))
2.12     ldr    r3, [fp, #-40]      ; 0x28
0.08     ldr    r2, [fp, #-268]   ; 0x10c
0.33     cmp    r2,
Press 'h' for help on key bindings

```



Real-Time Programming

